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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification [5] : F16F 7/12, B62D 21/15, 25/08

A1

(11) International Publication Number: WO 91/14110

(43) International Publication Date: 19 September 1991 (19.09.91)

(21) International Application Number: PCT/NO91/00034

(22) International Filing Date: 6 March 1991 (06.03.91)

(30) Priority data:
901062 6 March 1990 (06.03.90) NO

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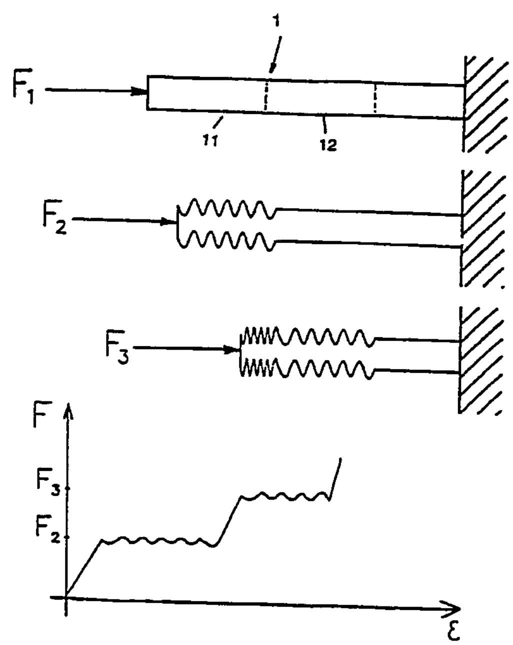
(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, KR, LU (European patent), NL (European patent), SE (European patent), US.

Published
With international search report.

(54) Title: ENERGY ABSORBING STRUCTURES AND METHOD OF PROVIDING SUCH STRUCTURES



(57) Abstract

Energy absorbing structure comprises a longitudinal bearing member (1) exhibiting variations in the material strength along its longitudinal axis achieved by a differential heat treatment of different parts of the bearing member.

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Energy absorbing structures and method of providing such structures

The present invention relates to energy absorbing structures used in assemblies exposed to impact loads to control the amount of resulting damages in the assembly and to protect the occupants or contents thereof. More particularly the invention relates to the energy absorbing structures incorporated in motor vehicle frames to absorb impact energy and to a method of providing such structures.

The ever increasing number of road accidents resulted in development of the present basic car body concept comprising a rigid cabin for occupants and deformable body parts having a high energy absorption capacity in the front and behind the cabin. Aluminium and its alloys, thanks to an excellent corrosion behaviour, good extrudability, high ductility and low specific weight, are consequently a natural material choice for the motor vehicle body parts. However, the specific mass energy absorption of an aluminium extrusion construction having the same stiffness as a steel sheet construction, which has so far been used as energy absorbing structures in vehicles, can be twice as high. Such substantially higher specific energy absorption applied in the front part of vehicles would result in higher forces acting on vehicle occupants during a frontal collision. This means that in order to achieve a complete control of the energy absorption

and the progressive collapse of the deformable body parts, ensuring a sufficient deceleration path so that the physical capacity of human bodies to survive a sudden stop is not exceeded, a simple swith over to application of e.g. extruded Al-shapes in the energy absorbing structure is not possible.

Several approaches are known from the prior art to resolve this problem by e.g. provision of several individual sections having different material characteristics being connected together by mechanical means or provision of reinforcing means attached outside or inside of the extruded shape on predeterminated locations along an underdimensioned cross-section of the shape.

Apart from offering a rather complicated solution comprising several parts and the necessity of a laborous assembling operation, the provision of reduced cross-section of the shape in the latter case also means reduced stiffness of the structure, which is not desirable for the normal handling and performance of the vehicle frame.

Consequently, it is an object of the present invention to provide a new energy absorbing structure avoiding the above drawbacks and offering a simple assembling of the structure.

This and other objects according to the present invention are achieved by provision of a longitudinal bearing member, as it appears from the characterizing part of claim 1 and claim 4, respectively.

The invention will now be described in more details by the way of examples and preferred embodiments referring to the accompanying Figures 1-2, where

Fig. 1 is a schematical cross-sectional view of the energy absorbing structure assembly, and

Fig. 2 illustrates graphically the energy/path characteristics of a heat treated longitudinal bearing member exposed to an increasing impact load.

Fig. 1 shows schematically a cross-section of a motor vehicle's front part comprising a longitudinal front bearing member 1 extending from a side sill 4 towards a bumper 2. A hydraulic impact absorber 3 extending between the bumper and the front brace is an optional additional equipment. Such hydraulic absorbers are installed in order to ensure that under a low speed collision, up to approximately 5 km/h, all the impact energy is absorbed without any permanent deformation of the front bearing member.

Impacts already at rather moderate speeds of from 15 to 20 km/h will result in a permanent deformation of the structure, especially the front bearing members, requesting repair or exchange of the deformed parts.

According to the present invention it has been found that by conducting a special heat treatment of the front part 11 of the longitudinal front bearing member 1 made of hardened Al-alloy its strength can be substantially reduced, while the stiffness of the whole member is unchanged. Simultaneously the ductility will increase and thus a better formability during deformation is ensured. In this way a complete control of the energy absorption can be achieved, e.g. almost 50% reduction of the energy absorption in the deformation zone 11 compared to the original material state condition.

Example 1

Tubes having diameters of 30 mm and a wall thickness of 2 mm were extruded of Al-alloy 6060 (AlMgSi 0.5) and aged at 185°C for 4 hours reaching a yield strength of 230 N/mm^2. Series of samples were then subjected to a following overageing heat treatment at 350°C, variating the exposure time from 5 to 30 minutes and measuring the material strength, see the following Table.

Sample No.	Exposure time at 350°C in min.	Yield strength in N/mm^2
0	0	230
1	5	220
2	10	185
3	15	165
4	20	150
5	25	130
6	30	120

Compression tests were conducted on the above heat treated tube samples having a height of 100 mm. The forces (loads) required to reduce the tubes down to 30 mm were measured for tubes treated at different temperatures. While a force of 40.7 kN had to be applied on the tube heat treated for 5 minutes, the force was reduced down to 22.3 kN for the tubes treated for 30 minutes, which represents a reduction of 45% (!).

Example 2

An extruded heat treated (aged) Al-alloy beam 1, as schematically illustrated in Fig. 2, has a front part 11 being exposed to an overageing heat treatment, e.g. by means of local induction heating of the part. The beam was then fastened in a fixture and axially subjected to a force F increasing stepwise from F1 to F3.

The resulting progressive compression deformation of the beam starting under the load F2 is limited to the overaged front part 11. Only at increased loads F3 also the adjacent beam part 12 starts to absorb the energy by folding. The attached Force/path diagram where F denominates applied force and ε deformation path, illustrates graphically the achieved axial deformation of the beam.

The actual applied forces to achieve the illustrated energy absorption by an axial compression deformation of the beam are besides being related to the applied type of alloys and heat treatment also dependent on the configuration (shape) of the beam and its dimensions. It is important that the temperature used is so low that the actual alloy material will not start any natural ageing after this heat treatment but remain stable over the time.

Obviously, there are several advantages connected to energy absorbing structural members provided according to the present invention. A whole single piece member can be provided in one step, e.g. by extrusion of an appropriate heat treatable Al-alloy and then subsequently differentially heat treated so that different deformation zones exhibiting different strength along the member are provided. Thus, referring to Fig. 1, the front part 11 of the longitudinal member 1 can be heat treated to reduce the energy absorption capability with approximately 50%, while the following parts (deformation zones) 12 and 13 will remain in e.g. half hard and hard conditions, respectively.

During a collision at moderate speed, e.g. below 35 km/h, only the front part 11 will be affected and deformed and could easily be exchanged by cutting it away and welding a new part 11 to the remaining parts 12 and 13. Only at higher impact loads also the parts 12 and 13 will absorb the impact energy by folding, bending and/or distortion demanding exchange of the whole structural energy absorbing member.

While the invention has been described in terms of preferred embodiments, it is apparent that modifications may be made therein without departing from the spirit or scope of the invention as set forth in the appended claims. The energy absorbing structure can also be used in e.g. containers for cargo to protect the cargo from damage or air landing pallets to absorb ground impact loads.

Claims

1. Energy absorbing structure, particularly in motor vehicles, to absorb the impact energy by an axial compression deformation, comprising a longitudinal bearing member (1),
c h a r a c t e r i z e d i n t h a t
the longitudinal member (1) is an integral metallic shape of substantially uniform cross-section exposed to a differential heat treatment and exhibiting variations in the material strength along its longitudinal axis.

2. Energy absorbing structure according to claim 1,
c h a r a c t e r i z e d i n t h a t
the integral longitudinal member (1) is an extruded aluminium alloy shape comprising several deformation zones (11,12,13) extending subsequently in the longitudinal direction, the zones being subjected to an individual differential heat treatment.

3. Energy absorbing structure according to claim 2,
c h a r a c t e r i z e d i n t h a t
the longitudinal member (1) is a front bearing member in a vehicle frame made of aged aluminium alloy and where the frontal deformation zone (11) is exposed to an overageing treatment.

4. Method of providing a longitudinal member suitable for use in energy absorbing structures,
c h a r a c t e r i z e d i n t h a t
the method comprises steps of
   - extruding of a shape of heat treatable aluminium alloy,

- ageing heat treatment of the shape at a predetermined elevated temperature, and finally
- an overageing heat treatment conducted on a limited part of the shape.

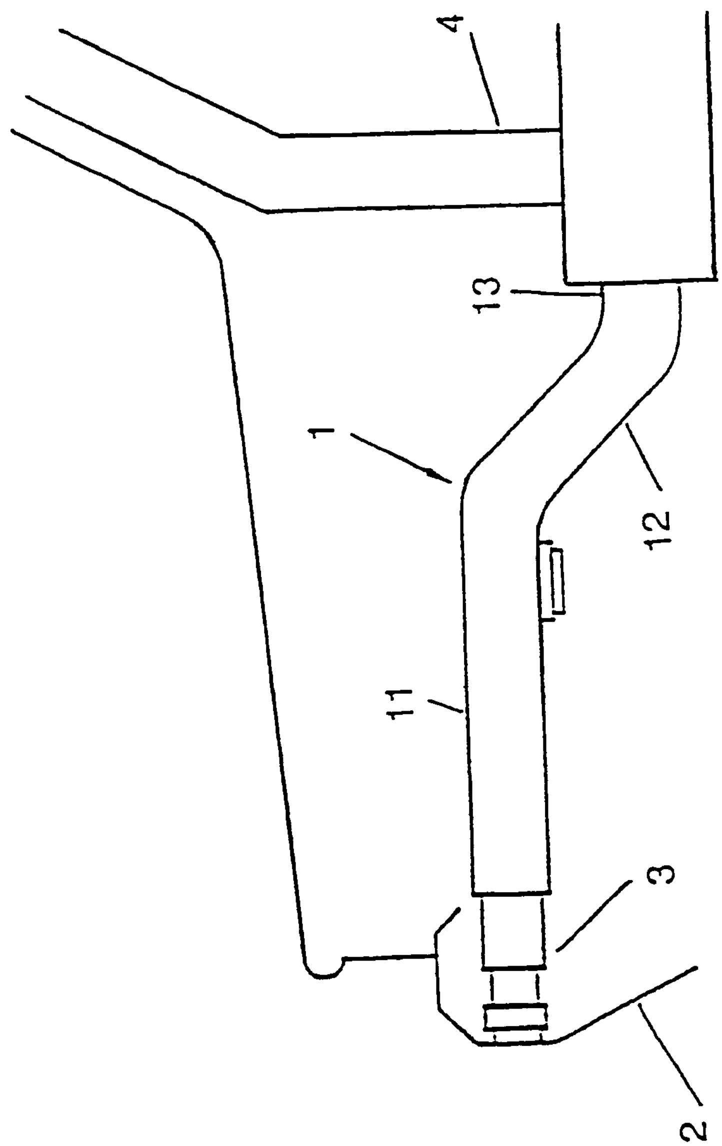

FIG. 1

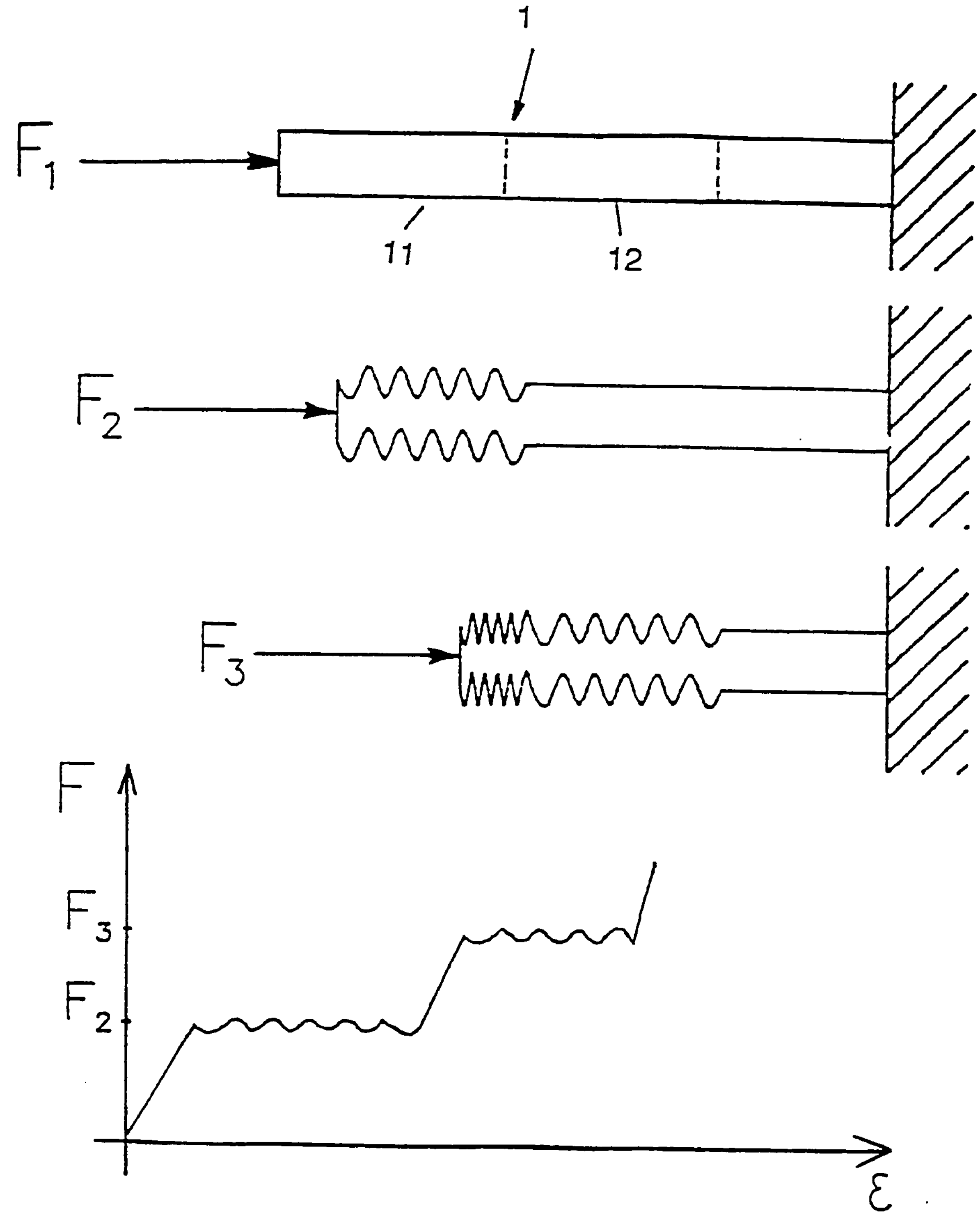

FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No PCT/NO 91/00034

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: F 16 F 7/12, B 62 D 21/15, 25/08

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	F 16 F; B 60 R; B 62 D

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	US, A, 3983962 (TORKE) 5 October 1976, see column 1, line 48 - line 63	1
Y	--	2-4
X	US, A, 4194763 (REIDELBACH ET AL) 25 March 1980, see column 2, line 11 - line 21; column 4, line 31 - line 32; abstract	1
Y	--	2
X	US, A, 4133549 (REIDELBACH ET AL) 9 January 1979, see column 2, line 64 - column 3, line 3 --	1
X	Patent Abstracts of Japan, Vol 7, No 211, M243, abstract of JP 58-105881, publ 1983-06-23 (TOYOTA JIDOSHA KOGYO K.K.) --	1

* Special categories of cited documents: [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
5th June 1991	1990 -06- 11
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	Marianne Dickman

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	EP, A1, 0303431 (SHOWA ALUMINUM KABUSHIKI KAISHA) 15 February 1989, see column 2, line 42 - line 47 --	2-4
A	US, A, 4152012 (REIDELBACH ET AL) 1 May 1979, see column 1, line 56 - column 2, line 8 --	1-2
A	US, A, 4023652 (TORKE) 17 May 1977, see column 2, line 45 - line 50; figures 1,3 --	1-2

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.PCT/NO 91/00034

This annex lists the patent family members relating to the patent documents cited in the above-mentioned International search report.
The members are as contained in the Swedish Patent Office EDP file on 91-04-30
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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		FR-A-B-	2315058	77-01-14
US-A- 4194763	80-03-25	DE-A-	2636655	78-02-16
		US-A-	4288025	81-09-08
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		US-A-	4907735	90-03-13
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US-A- 4023652	77-05-17	DE-A-B-C	2426938	75-12-11
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